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Research Article

Impact of Axial Length and Preoperative Intraocular Pressure on Postoperative Intraocular Pressure Changes in Non-Glaucomatous Eyes Following Phacoemulsification Surgery in a University Hospital

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Abstract

Objectives: To evaluate the changes of Intraocular Pressure (IOP) in non-glaucomatous eyes following Phacoemulsification surgery among patient groups with different Axial Lengths (AL).

Methodology: Within a retrospective cohort study design, medical records of cataract patients that underwent surgery between 2000 and 2010 at the Department of Ophthalmology, King Abdul-Aziz University Hospital (KAUH), Riyadh, Saudi Arabia were reviewed. Cases were identified as having an ocular AL >24 mm, <22mm, and a normal group of AL range; 22-24mm. The relationship between postoperative IOP changes and AL was evaluated for all patients fulfilling the inclusion criteria.

Result: Among the Department of Ophthalmology, KAUH reviewers that underwent surgery during the period from 2000 to 2010, 252 eyes of 211 cataract patients were included in the current study. Patients were in the mean (±SD) age of 60.3 (±10.4), 110 (52.1%) male and 101 (47.9%) female. The average preoperative IOP for the whole study group significantly decreased from preoperative value of 14.5 (3.3) to 13.9 (3.4) mmHg (p=0.005). Within the normal axial length group, the mean IOP was significantly reduced from 14.1 (3.2) at baseline to 13.5 (2.9) post operatively (p=0.035). Similar reduction was noticed among the longer axial length group (AL >24 mm) while slight increase was recognized in the smaller AL group (AL <22mm). However, both changes were not statistically significant (p= 0.067 and 0.640 for the long and the short AL groups, respectively). In the univariate analysis, "having preoperative high IOP" was the only associated factor with the postoperative decrease in IOP (p=0.034). This factor has also persisted to be significant in the binary logistic regression analysis (p=0.029).

Conclusion: Patients with relatively high preoperative IOP would have a considerable reduction in IOP posterior to Phacoemulsification procedure. Such anticipated reduction may be also applicable to eyes with moderate and long axial length. Phacoemulsification may also help reducing the need for postoperative anti-glaucoma medications among cases with ocular hypertension.

Keywords: Cataract; Glaucoma; Phacoemulsification; IOP; Saudi Arabia

Introduction

Cataract extraction using Phacoemulsification is considered as one of the most common surgical procedures done worldwide [1]. The role of Phacoemulsification in elimination of cataract and restoring vision is well documented in the literature [2]. In addition, it has a significantly interesting role in changing the postoperative intraocular pressure from its preoperative level [3]. The decrease of Intraocular Pressure (IOP) following Phacoemulsification may be beneficial for patients who suffer from high intraocular pressure as it may reduce their dependence on anti-glaucoma medications postoperatively.

Such procedure would play a crucial role in the process of surgeon's decision making on whether to conduct cataract surgery solely or to combine such surgery with one of the glaucoma procedures among glaucomatous patients. This critical decision is anticipated to be highly affected by the predictability of the postoperative IOP level. Therefore, reaching up to relatively accurate estimation of the postoperative IOP level would definitely change the surgical plan.

The mechanism of the decrease in the intraocular pressure following cataract surgery remains unclear [4]. However, there are multiple suggested mechanisms that would explain the clinically observed decrease in the IOP following cataract surgery such as angle anatomy that carries out a higher IOP reduction among angle closure glaucoma patients [2]. Besides anatomical factors, another explanatory theory suggests that, surgical lens extraction would lead

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to potential movement of the posterior capsule more posteriorly, displacing the zonula over the ciliary body, which, by its turn, facilitates more aqueous outflow as a result of Schlemm's canal expansion. Additionally, it has been theorized that Ultrasound's power during Phacoemulsification would lead to sudden elevation of the anterior chamber pressure; and hence stimulates the inflammatory cytokines, especially IL-1, which would again facilitate more aqueous humor outflow [5,6].

Moreover, some of the recently published studies have evaluated the relationship between ocular biometric parameters and post-op IOP reduction in normal eye patients such as: pre-op IOP, Anterior Chamber Depth (ACD), Axial Length (AL), angle opening distance, anterior chamber area, Central Corneal Thickness (CCT), lens thickness, iris thickness, and pupil diameter [7,8]. Nevertheless, this mechanism remains unclear although there is an increasing evidence reported that the greatest factor among all is the level of the preoperative IOP [4]. On the other hand, there is a controversial uncertainty whether the ocular axial length as defined by "the distance from the anterior corneal surface to the retinal-pigmented epithelium" would contribute a significant role in predicting the intraocular pressure changes following cataract surgery [4]. However, a previous study revealed that there is a potential association between the observed reduction in IOP and axial length of the eye [1]. For such controversy, the aim of this study is to investigate the changes of intraocular pressure in non-glaucomatous eyes following Phacoemulsification and to estimate the potential effect of preoperative intraocular pressure and axial length on the changes of postoperative IOP level in Phacoemulsification cataract surgeries.

Methods

In this retrospective cohort study, we attempted to evaluate the intraocular pressure changes in non-glaucomatous eyes with different axial length groups after cataract surgery, and to analyze the role of other possible preoperative, intra-operative, and post-operative risk factors. To fulfill such evaluation, medical records of cataract patients who underwent Phacoemulsification cataract surgery between 2000 and 2010 at the Department of Ophthalmology, King Abdul-Aziz University Hospital (KAUH), Riyadh, Kingdom of Saudi Arabia (KSA) were reviewed for both demographic and associated clinical data. Ethical approval was sought through the Institutional Research and Ethics Review Board (IRERB) of the College of Medicine, King Saud University, KSA, where the current study follows the Declaration of Helsinki for ethics of research involving human beings.

Sample size calculation was done to withdraw a representative sample of all Phacoemulsification cataract surgeries operated at KAUH in the targeted time frame. The final estimated number of eyes was 500 out of around 4000 eligible cataract surgeries operated at the hospital. Inclusion criteria were having cataract surgery done with Phacoemulsification technique, being in the age interval of 40 years and above and having completed a minimum of 12 months of follow-up. Meanwhile, the exclusion criteria implied any case with other ocular comorbidity, having clinical evidence of glaucoma, open injury trauma, ocular inflammatory conditions such as uveitis or undergoing any previous and / or combined surgery.

We stratified the data per annual strata, from which our sample was systematically withdrawn. This stratification was based on time factor, to avoid selection bias and to enable equal probability for each cataract surgery case to appear in our sample. Medical files of selected file numbers were retrieved and reviewed, where a specially designed form was formulated to collect the required data, which were collected in a retrospective fashion from the recruited patient's medical records. The data sheet included age, gender, past ocular history, past medical history, number of anti-glaucoma medications, previous ocular surgeries, preoperative non-corrected and best-corrected visual acuity, pre- and post-operative Intraocular Pressure (IOP), clarity of cornea, type of cataract recorded based on the slit lamp, and axial length as measured by either ultrasound or other optical measurement tools. Intraoperative data included: type of anesthesia, surgical technique, level of surgeon, occurrence of posterior capsular rupture, vitreous loss, suprachoroidal hemorrhage, intraocular lens implantation, and position of intraocular lens implantation. The primary outcome of interest was postoperative IOP. Additionally, we investigated the potentially associated risk factors including; age, gender, laterality of the eye, type of cataract and surgery, preoperative IOP, and axial length.

Statistical methods

Data were collected and stored in a spreadsheet using Microsoft Excel 2010® software. Data management and coding were both done in Excel. Data were analyzed using SPSS® version 20.0 (IBM Inc., Chicago, Illinois, USA). Descriptive analysis was done, where categorical variables were presented as frequencies and percentages and continuous variables as mean and standard deviation (±SD). Inferential analysis was done where Student's T test was used to investigate any significant difference between pre- and post-operative mean IOP values. Chi^2 (Fisher exact test when indicated) was used to detect the association between categorical variables in the univariate analysis. Finally, binary logistic regression analysis was done to measure the effect size of risk factors on the IOP Change. Confidence interval level was set to 95% where a corresponding p value threshold was identified as 0.05. Accordingly, p values < 0.05 were interpreted as denoting statistical significance.

Results

In the current study, we recruited a total of 252 eyes of 211 patients where 170 (67.5%) were unilateral and 82 (32.5%) were bilateral. Patients were in the mean (±SD) age of 60.3 (±10.4), ranging between 40 and 90 years. Males; 110 (52.1%) slightly exceeded females 101 (47.9%) with operated ODs (123; 48.8%) slightly higher than OSs (129; 51.2%). The average preoperative IOP for the whole study group at baseline was 14.5 (3.3) mmHg, which significantly decreased to 13.9 (3.4) mmHg following Phacoemulsification cataract surgery (p=0.005). Moreover, among the group with normal axial length (22 – 24 mm; n=156 eyes), the mean IOP was significantly reduced from a preoperative value of 14.1 (3.2) to 13.5 (2.9) post operatively, (p=0.035). Similar reduction was noticed among the longer axial length group >24 mm (n=73 eyes) from preoperative value of 15.4 (3.5) mmHg to 14.6 (4.0) mmHg postoperatively. Nevertheless, such reduction did not reach up to the statistical significance threshold (p=0.067). Similarly, the change among the group with shorter axial length <22 mm (n=23 eyes) relatively raised from a preoperative value of 14.4 (2.9) mmHg to a postoperative level of 14.6 (4.0), however, insignificantly (p=0.640) (Table 1).

Table 1: Comparing pre and post data using Wilcoxon test (the data was not normally distributed after performing Kolmogorov-Smirmov Test).

	Whole group (n=252 eyes)	Axial Length <22mm	Axial Length 22 – 24mm	Axial Length >24mm
Variable	Mean (SD)	(n=23 eyes)	(n=156 eyes)	(n=73 eyes)
		Mean (SD)	Mean (SD)	Mean (SD)
Pre IOP (mmHg)	14.5 (3.3)	14.4 (2.9)	14.1 (3.2)	15.4 (3.5)
Post IOP (mmHg)	13.9 (3.4)	14.6 (4.0)	13.5 (2.9)	14.6 (4.0)
P value	0.005*	0.64	0.035*	0.067

*Statistically significant at 5% level of significance.

Table 2: Univariate analysis for factors associated with IOP reduction (Chi-square).

Variable	IOP Reduction		*P* Value
	Positive (n=163) n (%)	Negative (n=89) n (%)	
Age (years)			
≤60 (n=143)	87 (60.8)	56 (39.2)	0.144
>60 (n=109)	76 (69.7)	33 (30.3)	
Gender			
Male (n=134)	90 (67.2)	44 (32.8)	0.380
Female (n=118)	73 (61.9)	45 (38.1)	
Laterality			
Unilateral (n=170)	107 (62.9)	63 (37.1)	0.405
Bilateral (n=82)	56 (68.3)	26 (31.7)	
Eye			
Right (n=123)	78 (63.4)	45 (36.6)	0.681
Left (n=129)	85 (65.9)	44 (34.1)	
Type of cataract			
NS (n=124)	77 (62.1)	47 (37.9)	0.398
Others (n=128)	86 (67.2)	42 (32.8)	
Vision			
≤20/40 (n=25)	19 (76.0)	6 (24.0)	0.212
>20/40 (n=227)	144 (63.4)	83 (36.6)	
Pre IOP (mmHg)			
≤21 (n=244)	155 (63.5)	89 (36.5)	0.034*
>21 (n=8)	8 (100.0)	0 (0.0)	
Axial Length (mm)			
<22 (n=23)	16 (69.6)	7 (30.4)	0.716
22-24 (n=156)	98 (62.8)	58 (37.2)	
>24 (n=73)	49 (67.1)	24 (32.9)	

*Statistically significant at 5% level of significance.
NS: Nuclear Sclerotic, IOP: intraocular pressure.

In univariate analysis, the only variable that showed significant association with reduction in IOP was: having preoperative IOP higher than 21 mmHg (p=0.034). Where the categorized axial length variable became statistically insignificant (p=0.716). (Table 2) Furthermore, conduct of comparison of mean test to investigate whether there is a significant difference between different categories in terms of the amount of IOP reduction confirmed that the pre-intervention level of intraocular pressure was still the only significant factor affecting the overall reduction in IOP (p<0.001) (Figure 1).

Additionally, we used binary logistic regression analysis to estimate the exact effect size of different variables on the postoperative reduction in IOP. Findings from the logistic regression revealed that the pre-intervention mean IOP was still statistically significant after adjusting for all other factors (p=0.029).

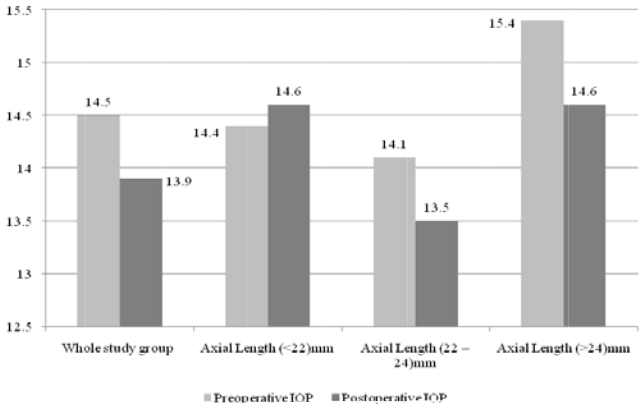

Figure 1: IOP changes following cataract surgery among different axial length groups.

Discussion

Cataract surgery seems to lower the intraocular pressure on a constant basis, especially in patients with higher preoperative intraocular pressure. The mechanism of action of these findings remains speculative. The conventional understanding that cataract surgery lowers IOP by around two to four mmHg for a couple of years was partially confirmed by a specified meta-analysis study. This meta-analysis showed a long term mean IOP reduction of two to four mmHg among cataract patients who underwent surgery. However, the study did not provide a convenient long term follow-up. Meanwhile, it seems that Phacoemulsification procedures would lower the IOP more than manual extra capsular cataract extraction [9-12].

In this study, findings from our series show that, the intraocular pressure was significantly reduced following Phacoemulsification and Intraocular Lens (IOL) implantation in non-glaucomatous patients. Such findings have been reported in a number of similar studies. Poley et al., [5] reported a long-term (up to 10 years) reduction of postoperative IOP following Phacoemulsification regardless of age. Furthermore, both Tenzel et al., and Poley et al., reported that the achieved reduction of IOP after cataract surgery in individuals with Open-Angle Glaucoma (OAG), Ocular Hypertension (OH), or Normal Tension Glaucoma (NTG) have reduced the need for postoperative anti-glaucoma medications [5,13,14]. In consistence with such findings, Kim and Hyung have also reported that

Phacoemulsification and IOL implantation showed a significant reduction in IOP in patients with chronic Angle-Closure Glaucoma (ACG) [15].

Meanwhile, in our study, the associated risk factors with IOP reduction were; the preoperative IOP and the axial length, while age, gender, laterality, operated eye, type of cataract, type of surgery, and visual acuity were not found to be statistically significant factors. These findings agree with findings by Tong JT et al., which highlighted that; age, sex, the operated eye in addition to the type of anesthesia didn't significantly influence the detected postoperative changes in IOP [16].

Generally speaking, among all of the investigated parameters, preoperative IOP is highly suggested as a significant predictor of IOP reduction. This fact is also supported by a retrospective study which showed that the postoperative reduction in IOP is proportional to the preoperative IOP value as well as a recent review which have also concluded that; the preoperative IOP is the best predictor of the postoperative IOP [6,13].

Additionally, this study showed a statistically significant correlation between axial length and the postoperative IOP; where eyes with normal (AL: 22 – 24) and longer AL (>24 mm) had a major reduction in IOP compared to eyes with shorter AL (<22 mm) which had unexpected relatively moderate raise in IOP in the postoperative assessment visits. Unsurprisingly, our findings disagree with findings from some other studies. One example is findings from a study by Cho et al., [17] that evaluated 71 eyes following Phacoemulsification. The study which grouped patients into 4 categories based on their AL: (21 to <23 mm), (23 to <25mm), (25 to <27mm), and (≥27) has found a major decrease in postoperative IOP among shorter AL group in contrary with the detected IOP increase among the longest AL group. These findings are also contradicting with findings by Yun et al., study (2013) which demonstrated that; axial length was not significantly associated with IOP reduction after cataract surgery in normal eyes [8]. Additionally, from another perspective, Kashiwagi et al., have reported significant reduction of IOP among patients with shallow preoperative Anterior Chamber Depth (ACD) and short AL [18].

The current study faced a number of limitations of which is the relatively small sample size of short AL group and the strict exclusion criteria which may have affected proper detection of the associations understudy. Therefore, our findings may be confirmed by conducting of a larger population-based study. Meanwhile, the retrieved postoperative IOP may have not been assessed in a standardized way, which again may have distorted the investigated associations. In addition to that, surgeries were performed by different surgeons/residents which may have affect our results as well. However, this study has another advantage which is assessing factors affecting postoperative IOP change in non-glaucomatous eyes following cataract surgery. Thus, it may help the surgeon in his preoperative decision making process on selection of suitable management strategies to reduce the risk of complications among glaucoma patients.

In conclusion, based on our study findings, patients with relatively high IOP prior to Phacoemulsification procedure would have a considerable potentiality to achieve a convenient postoperative decrease in IOP. Such anticipated reduction may be also applicable to eyes with moderate and long axial length. Phacoemulsification may also help reducing the need for postoperative anti-glaucoma medications among cases with ocular hypertension.

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